National Institute of Environmental Health Sciences

Integrating biophysical models and evolutionary theory to predict climatic impacts on species' ranges: The dengue mosquito Aedes aegypti in Australia

Author(s): Kearney M, Porter WP, Williams C, Ritchie S, Hoffmann AA
Year: 2009
Journal: Functional Ecology. 23 (3): 528-538

Abstract:

Climate change will alter the distribution and abundance of many species, including those of concern to human health. Accurate predictions of these impacts must be based on an understanding of the mechanistic links between climate and organisms, and a consideration of evolutionary responses. Here we use biophysical models of energy and mass transfer to predict climatic impacts on the potential range of the dengue fever vector, Aedes aegypti, in Australia. We develop a first-principles approach to calculate water depth and daily temperature cycles in containers differing in size, catchment and degree of shading to assess habitat suitability for the aquatic life cycle phase. We also develop a method to predict potential climatic impacts on the evolutionary response of traits limiting distribution. Our predictions show strong correspondence with the current and historical distribution and abundance of Ae. aegypti in Australia, suggesting that inland and northern limits are set by water availability and egg desiccation resistance, and southern limits by adult and larval cold tolerance. While we predict that climate change will directly increase habitat suitability throughout much of Australia, the potential indirect impact of changed water storage practices by humans in response to drought may have a greater effect. In northern Australia, we show that evolutionary changes in egg desiccation resistance could potentially increase the chances of establishment in a major centre (Darwin) under climate change. Our study demonstrates how biophysical models of climate-animal interactions can be applied to make decisions about managing biotic responses to climate change. Mechanistic models of the kind we apply here can provide more robust and general predictions than correlative analyses. They can also explicitly incorporate evolutionary responses, the outcomes of which may significantly alter management decisions.

Source: http://dx.doi.org/10.1111/j.1365-2435.2008.01538.x

Resource Description

Climate Scenario :

specification of climate scenario (set of assumptions about future states related to climate)

Special Report on Emissions Scenarios (SRES)

Special Report on Emissions Scenarios (SRES) Scenario: SRES B1

Early Warning System:

resource focus on systems used to warn populations of high temperatures, extreme weather, or other elements of climate change to prevent harm to health

A focus of content

Exposure :

weather or climate related pathway by which climate change affects health

Ecosystem Changes, Temperature

Temperature: Fluctuations

Geographic Feature:

resource focuses on specific type of geography

None or Unspecified

Geographic Location:

resource focuses on specific location

Non-United States

Non-United States: Australasia

Health Impact:

specification of health effect or disease related to climate change exposure

Infectious Disease

Infectious Disease: Vectorborne Disease

Vectorborne Disease: Mosquito-borne Disease

Mosquito-borne Disease: Dengue

Medical Community Engagement:

resource focus on how the medical community discusses or acts to address health impacts of climate change

A focus of content

Mitigation/Adaptation:

mitigation or adaptation strategy is a focus of resource

Adaptation

Model/Methodology:

type of model used or methodology development is a focus of resource

Exposure Change Prediction

Resource Type:

format or standard characteristic of resource

Research Article

Timescale: ☒

time period studied

Medium-Term (10-50 years)

Vulnerability/Impact Assessment: ☒

resource focus on process of identifying, quantifying, and prioritizing vulnerabilities in a system

A focus of content